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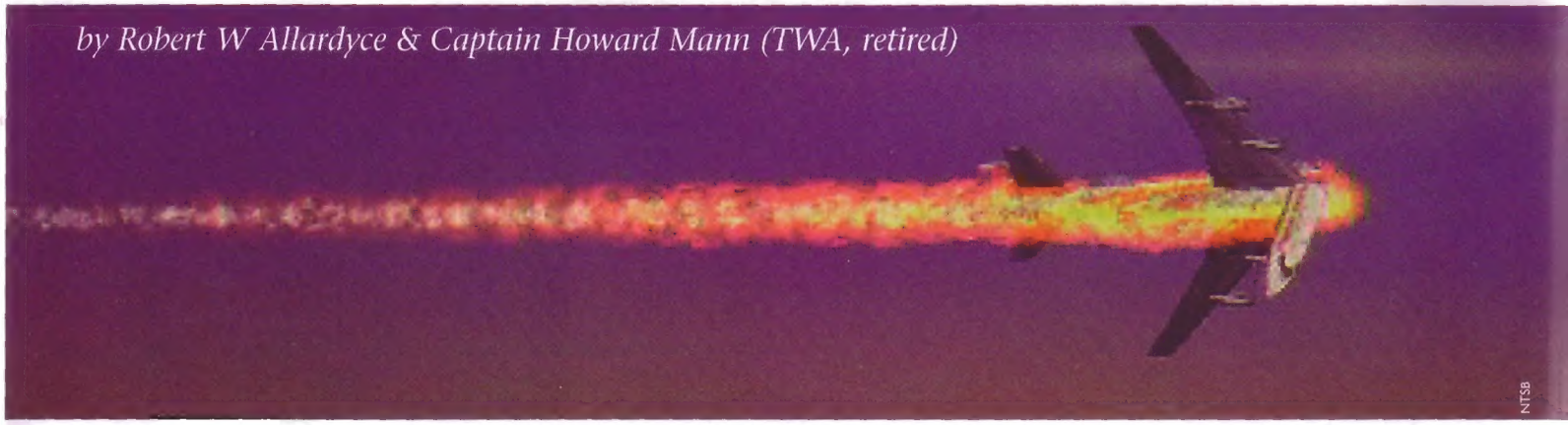
AIRWAYS CLASSICS Nº 2

# TWA Flight 800

## The Devil is in the Details

*by Robert W Allardyce & Captain Howard Mann (TWA, retired)*




On the evening of July 16, 1996, a few minutes after departing from New York's JFK International Airport, just over the Atlantic Ocean, a devastating explosion ripped TWA's Paris-bound Boeing 747 to shreds. All 230 souls on board perished instantaneously. In the hours that immediately followed the tragedy, TV news programs called on expert after expert, soliciting their opinions. There was almost unanimous agreement: evidence of missile-strike or bomb would soon be found. Within a few days, however, the emphasis slowly shifted. Some would say that a cover-up had begun. Attention centered on the 747's center wing fuel tank (CWT) and the presumed-to-be 'volatile' vapors given off by some 50USg (190l) of residual aviation kerosene alleged to have been trapped and sloshing around amongst the structural supports that made up the bottom of the tank.

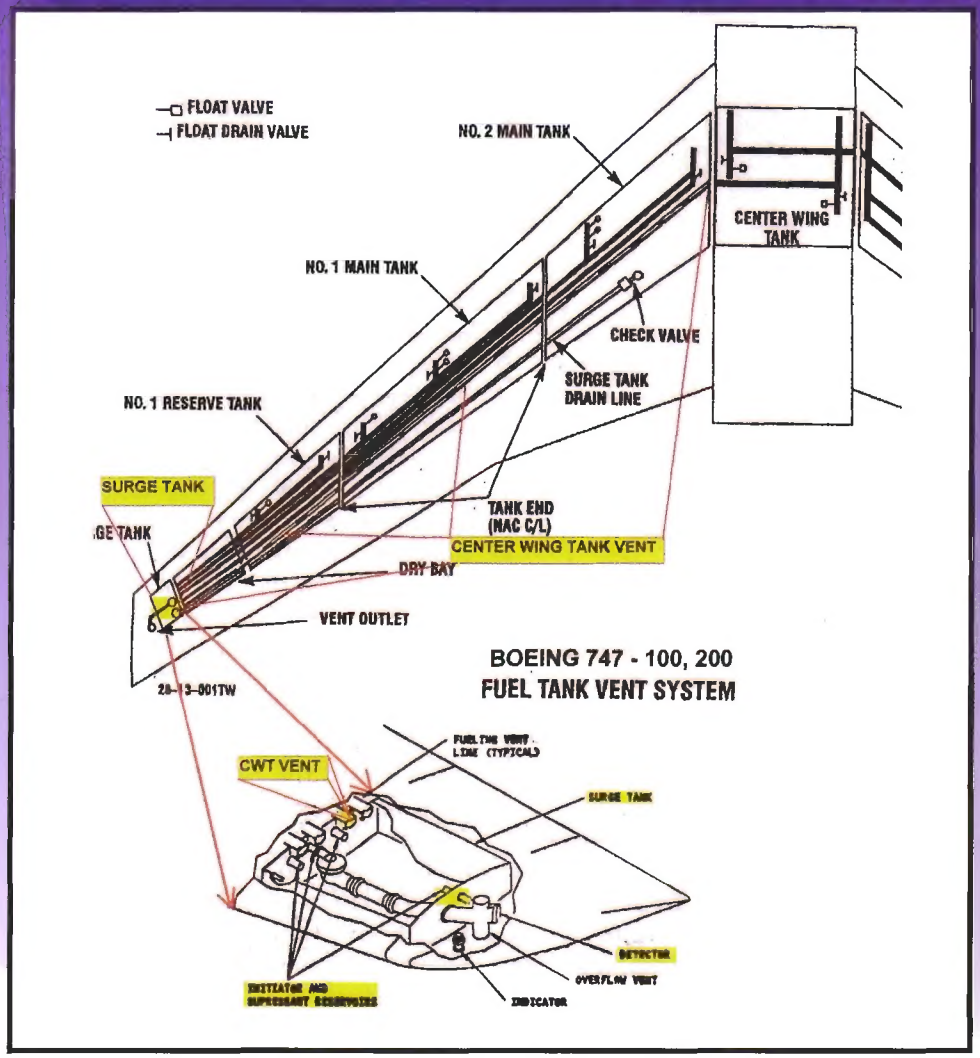
After a lengthy investigation, on November 17, 1997, the National Transportation Safety Board (NTSB) issued its final report *(NTSB: DCA-96-MA-070)*. The culprit, according to the NTSB, was the effluvium exuding from the puddle of fuel in the CWT. A mysterious spark allegedly ignited the fumes. In a single catastrophic explosion, the entire fuselage forward of the leading edges of the wings popped off much as a loosened cork is expelled from a champagne bottle.

Enter Captain Howard Mann, a retired TWA pilot. Given Mann's career-long interest in air safety in general and crash investigation specifically, it was inevitable he would become deeply involved in the investigation that followed the crash of one of TWA's own. After checking with the flight engineer who earlier that day crewed the 747 inbound from Athens, as well as with Boeing's engineers, Howard Mann did some careful calculations. He determined there could hardly have been more than 7USg (26l) of kerosene spread over the bottom of the CWT. Under the most favorable conditions, had the entire seven gallons turned to vapor, the energy produced by combustion could not have generated the destructive power that had obviously occurred.

The NTSB's path to its final conclusion that the fuel vapors in the CWT exploded had been a rocky one. Too little scientifically-based knowledge about the explosive properties of aviation grade kerosene (Jet A) was available. However, from the beginning, it was apparent that the investigators had assumed that Jet A was as volatile as the infamous JP-4 used by the military, a mixture of aviation kerosene and 140-octane aviation gasoline. Reality, unfortunately, refused to cooperate. A series of failed experiments followed. During one test, for example, propane had to be added to Jet A fumes to create the much-sought-after eruption. As the flurry of experiments progressed, the issue of an explosion inside the CWT—as the primary event that shattered the 747—became obscured behind a veritable mountain of data that not only explored the combustibility of Jet A, but also investigated the power and duration of the unidentified spark that had supposedly set the whole thing off. With all these distractions, the NTSB's officialdom never seemed to feel a need to re-examine its initial premise.

We hasten to say that we do not deny that there was an explosion of some kind inside the CWT. However, we insist that this flare-up was not the primary event that triggered the series of catastrophic structural failures. We believe that NTSB investigators quickly jumped to the conclusion that the burst inside the CWT was the primary event and then went about back-filling with whatever evidence was needed to support their theory. Unfortunately, the resulting body of data is too complicated and voluminous to be reproduced in its entirety here.

On September 3, 1996, under the heading 'Breaking News', *US News Online* reported, "Early results from [Boeing's] tests tend to strengthen theories that a bomb or missile brought down TWA Flight 800..." The article continued: "After using computer models to simulate pressure within a 747's center fuel tank, Boeing engineers estimated 30 to 40 pounds per square inch [2-2.7 atmospheres] of pressure inside the tank




would be needed to do the kind of damage to the fuselage observed in the jet's remains." And, "[Boeing's] tests indicate that an internal explosion of the tank, caused by a malfunction, would generate a third less pressure than that, according to the investigator, who spoke on the condition of anonymity." Boeing's tests were generally discounted as having been self-serving.

Our focus is on some of those infamous 'details' in the form of a series of 'loose ends' that have been either unrecognized or studiously ignored by the NTSB. Any 'Probable Cause' that does not adequately account for these loose ends cannot be accepted as valid.

One such loose end has to do with the two Surge Tank Protection (STP) photoelectric sensors—one in each wingtip—and their canisters of inerting gas. Neither sensor had detected a 'flame-front' and, therefore, neither had triggered a discharge of inerting gas. Another loose end is the cockpit's Engine Pressure Ratio (EPR) indicators. Still securely mounted in their center instrument panel, these gauges were 'frozen' at power settings consistent with climb power. These and other anomalies will be explored in sequence.

Of the Surge Tank Protection system (see above), TWA's *747-100 Flight Handbook* offers the following description: "Each wingtip fuel tank vent is protected by a small fire extinguisher canister referred to as Surge Tank Protection or STP. Discharge of the canister is automatically controlled by a photoelectric [sensor]. Flight deck control is limited to system test of left and right wing canister[s]."

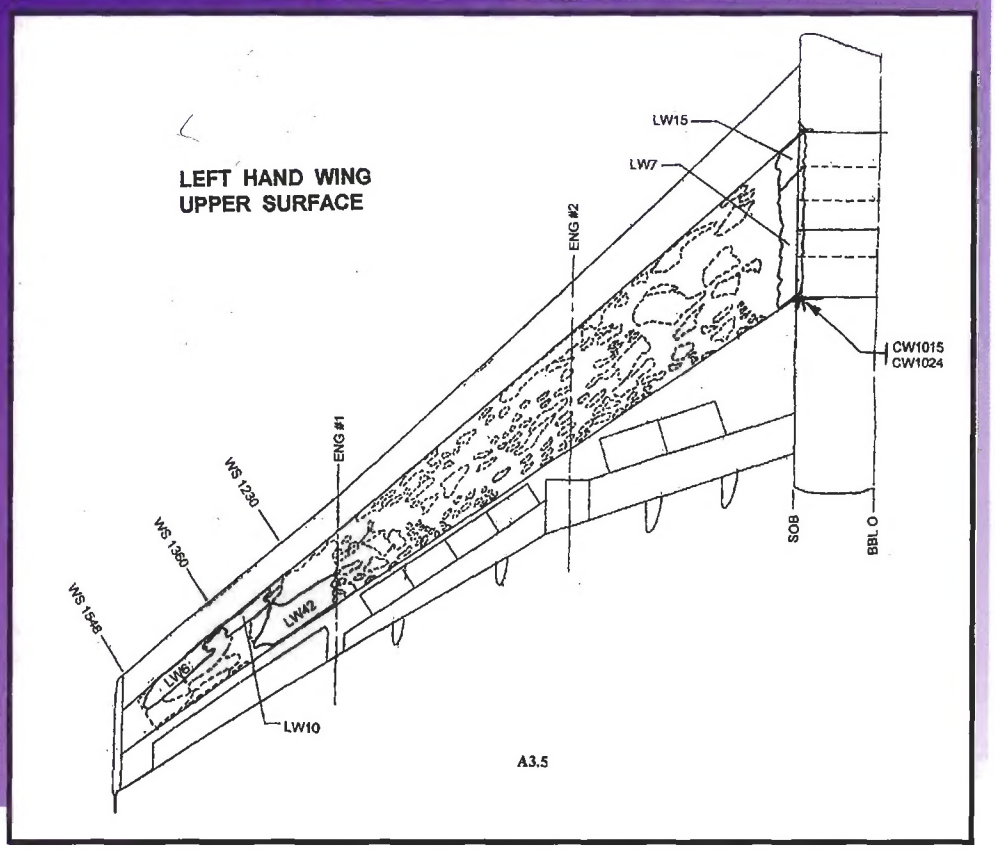
Highlighted in yellow, the photoelectric sensor was mounted on the outboard wall of each surge tank opposite the open end of the CWT's tank vent. Had a flame-front emerged from the CWT's tank vent, that photoelectric sensor was positioned to detect it and, within nanoseconds, flood the surge tank with inerting gas. Here is what the NTSB offered: "Although details of fire and soot documentation were performed by the Fire/Explosion Group, general observations of fire damage (or lack thereof) to the airplane systems were made by the Systems Group." Toward the end of the paragraph the NTSB added, "Soot was found in the vent stringers routed beyond the CWT to the right wingtip, but components in the wingtip surge tanks were not burned. The Surge Tank Protection (STP) system extinguishing agent had not been discharged from the intact bottles."

It is here that some imagination is required. Picture, in slow motion, a spark igniting a fire inside the CWT. The fire instantaneously transitions into an explosion. A shock wave emanates outward in all directions from the point of ignition. For visualization purposes, at the shock wave's leading edge, like an expanding bubble, there is a 'flame-front'—a thin wall of fire. This flame-front reaches the inner walls of the tank and pressure inside the tank rapidly builds. The vents of the CWT tank, open at their far end to the atmosphere, become unresisting pathways for the flame-front to make its escape to the surge tanks. As the flame-fronts enter the respective surge tanks, photoelectric sensors, opposite the open ends of the vent tubes, detect the passing of the flame-front. High-pressure canisters of inerting gas are instantly triggered and the surge tanks are filled with inerting gas. The point being that, had the CWT explosion been the sole initiating event, the photoelectric sensors would have released the contents of their canisters. This further suggests that the pressure from the CWT explosion had not yet built to the point where it had severed the front end of the fuselage, thereby knocking out the 747's electrical system, as depicted by the NTSB (opposite).

Clearly, neither of the two STP photoelectric sensors detected the presence of fire. So, the question is: Why didn't the photoelectric sensors react?

There can be only two possible answers: one is that electrical power to the photoelectric sensors failed before the pressure-propelled flame-fronts reached the wingtip surge tanks; or, the outer wing panels had already broken free of the inner wing panels, therefore the continuous passageway between CWT and surge tanks no longer existed.

The importance of the NTSB report's observation about soot in the fuel tank vent stringers, but no evidence of burning of components in the wingtip surge tanks, cannot be overstated. Because there was no evidence of fire inside the surge tanks for the




photoelectric sensors to detect—that is, sooting in the vent tubes took place later—this leaves the second of the two options above: by the time the CWT exploded, the wingtips had already been ripped away by a prior event. In other words, whatever combustion occurred inside the CWT was as a 'secondary event'. So, what was the 'primary event'? What was it that caused both of the wingtips to break free of the main wing sections?

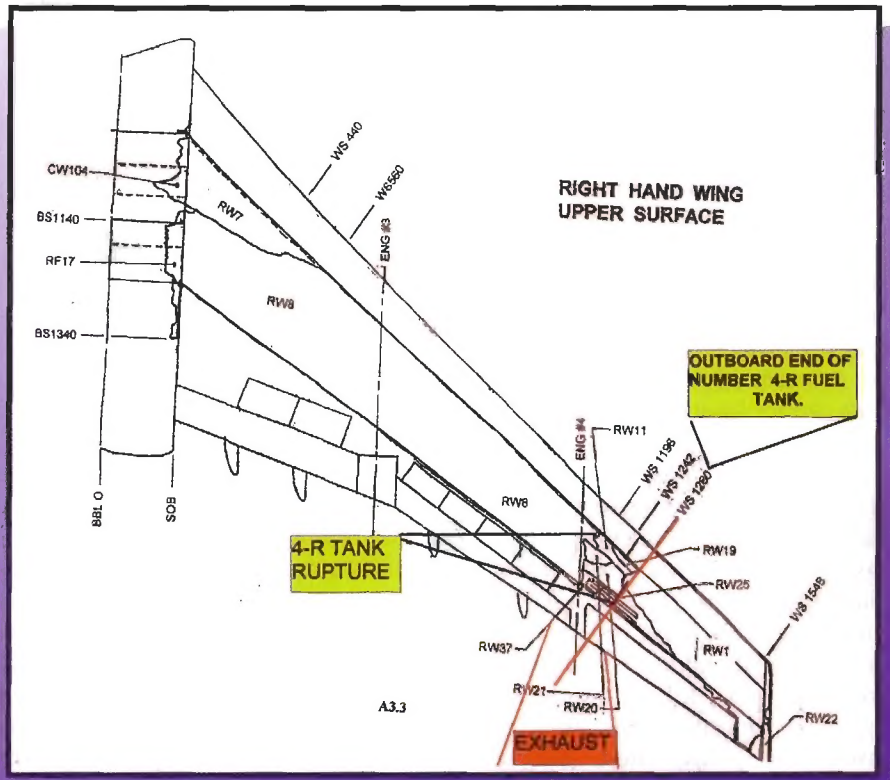
In reporting the condition of the wrecked left wingtip (above)—another loose end—the NTSB states: "The left wing outboard of about Wing Station (WS) 1230 [outboard of engine Nº 1] broke into eight larger pieces and numerous smaller pieces. Layout of these pieces showed upward bending outboard of about WS 1230 (LW 8 & LW 42) and possible down bending outboard of WS 1360 (LW 5 & 6, LW 44). Both upper and lower wing skin panels between WS 1230 and WS 1380 showed upward curling at the inboard end (upper panel LW 42 and lower panel LW 8)." Between WS 1230 and WS 1360 is where the wingtip broke free.

Of the badly damaged right wingtip (right), the NTSB reports: "The outboard wing section measured approximately 29 feet [8.84m] and comprised the wing from approximately WS 1242 (at the front spar and leading edge) to the wingtip. The wing structure between the inboard and outboard sections (WS 1224 to WS 1482) had broken into several pieces." In the next paragraph, the NTSB notes evidence of upward pressure on the right inboard wing where the breakage occurred. If the separations were not nearly simultaneous and one wingtip broke free first, the 747 would have rolled more severely than it did toward the loss of lift. The remaining wingtip, then, would have been subjected to downward not upward pressure. Similarities between the diagrams show the way both upper skins splayed upward as they tore loose. This speaks of near-simultaneous upward pressure on both wingtips.

The concept of upward pressure is best demonstrated if an arm is allowed to protrude from the window of a moving car. If the palm of the hand is kept parallel to the surface of the road, the hand easily 'cuts' through the wind. If, however, the leading edge of the palm is rotated upward slightly, around its latitudinal axis, there is a quick and sometimes dramatic result. The pressure of the wind on the palm abruptly forces the hand upward and backward. This is essentially what happened to Flight 800. An abrupt application of force tore the wingtips off.

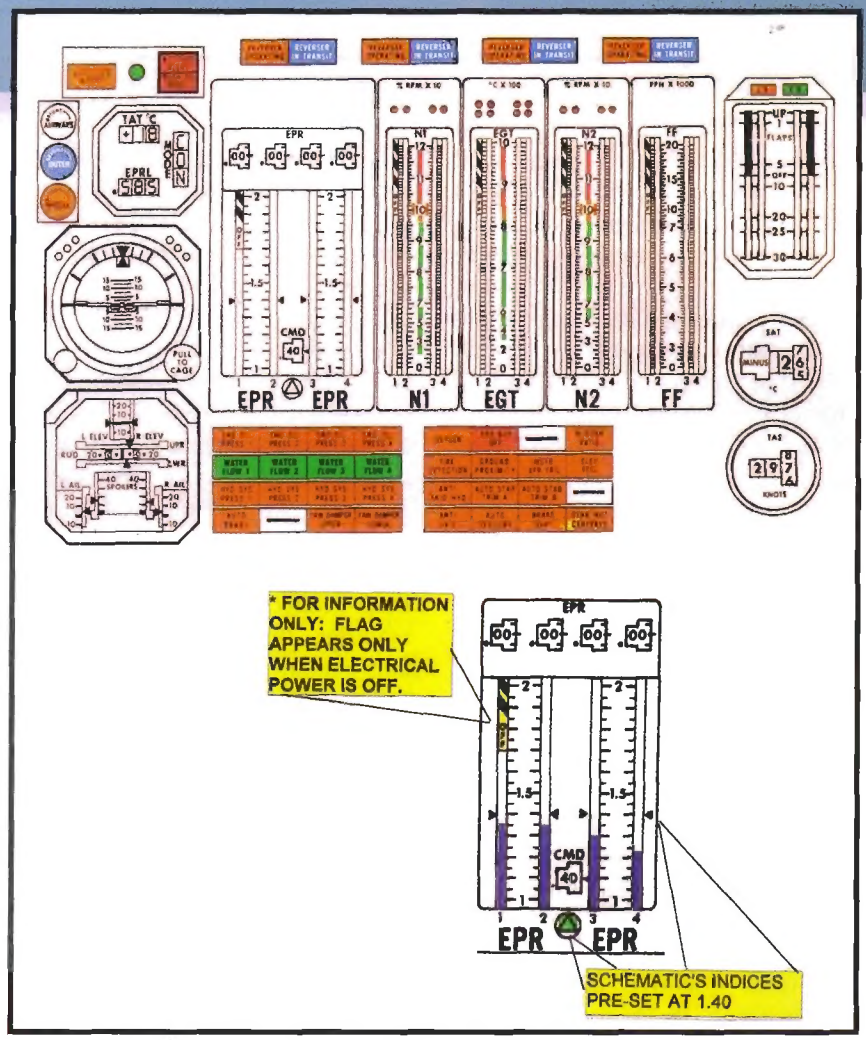
This prompts the next question: What caused the 747 to suddenly pitch nose up? Flight 800, according to its Cockpit Voice Recorder (CVR), had been cleared by Air Traffic Control (ATC) to climb to 15,000ft. The airplane's four thrust levers had been set to climb power. Everything seemed normal. So, what happened?

Movement of an airplane around the latitudinal axis (an imaginary line running approximately wingtip-to-wingtip across the airframe) is controlled by: the elevators; the position of the




*Photographed on approach to JFK four months before the accident, Boeing 747-131 N93119 operated TW800 on July 16, 1996.*

horizontal stabilizer; and, to a degree, the power of the low-slung turbine engines. If the elevators are deflected upward, the nose pitches upward. On the other hand, if the leading edges of the horizontal stabilizers move downward, that too, would work to force the nose upward. Adding or subtracting power to the engines tends to rotate the aircraft around its longitudinal axis. To pilots, this is basic stuff. The movements of the two control surfaces, however, are generally done only in measured applications, often by only a slight pressure by the pilot on the elevator control column. Likewise, adjustments to the trim of the horizontal stabilizers are sensitively done by short applications of electrical power to the trim mechanism. However, the stream of data recorded by the ship's Digital Flight Data Recorder (DFDR) shows the engines had already been set to climb power and there was no indication that the pilots had moved their flight controls. Reasoning suggests that fuel vapors in the CWT could not yet have ignited. So, what might have caused a sudden and dramatic displacement of the elevator control surfaces?




TWA's *Flight Handbook* offers one possible clue: "...a series of cables and links mechanically transmit control movement to the inboard elevator control valves. When the inboard elevators move, they mechanically position the opposite outboard elevator control valves to move the outboard elevators. Each inboard elevator is moved by a dual tandem actuator powered by a dual hydraulic source. The outboard elevators are moved by an actuator powered by a single hydraulic source." The point to be appreciated here is that the elevators' hydraulic actuators are in the tail of the airplane. Control links and cables that command the control valves run nearly the full 232ft (70.7m)-length of the fuselage from cockpit to tail. With the hydraulic system operating, anything that moves control cables along their way between the cockpit and the tail would cause the elevators to react.

However, the data recorded by the DFDR did not indicate movement of the elevators. Howard Mann believes there is a more likely cause of the violent upward pitch—when the concussion that froze the EPR indicators reached the horizontal stabilizers, the shock broke them free of the mechanical collar that followed the movements of the jackscrew. The horizontal stabilizers are designed in such a way as to be aerodynamically downloaded. That is, with the stabilizers able to move freely, their leading edges would snap downward instantly forcing the nose of the 747 upward. Note, here, the wording of the NTSB's report concerning the jack screw's condition after recovery: "The jack screw extends above the jack screw fitting by ten

threads and is fractured at the bottom of the fitting." The jack screw had indeed broken free. However, the NTSB attributed this to damage done upon impact with the water; it can be no more than a convenient guess. Consistent with the evidence, the damage occurred in flight as a result of the severe impact of a powerful shock wave resulting in an instant and severe pitch-up.

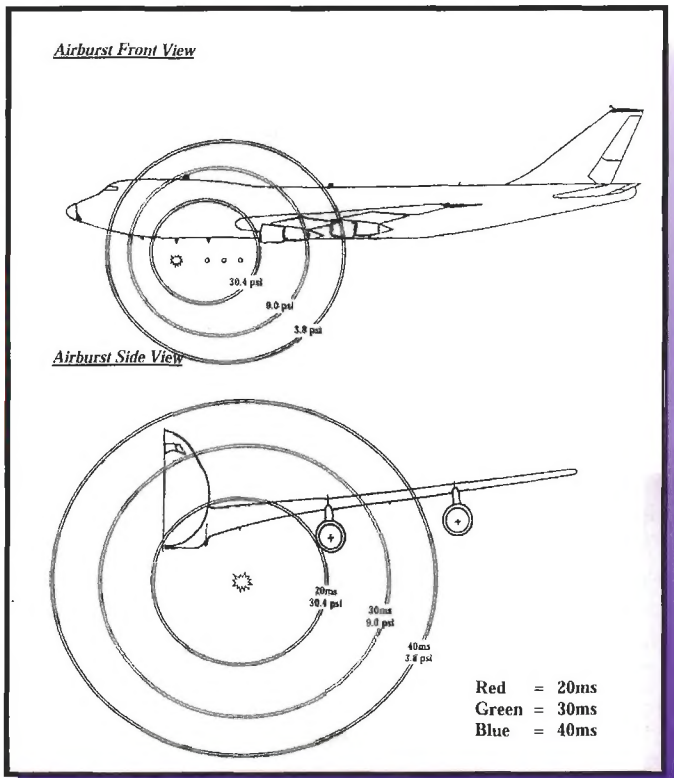
Just forward of the left wing root, the explosion tore the stress-distributing skin of the tube-like monocoque fuselage. That rip in the skin not only weakened structure, it worked to focus the stress caused by the pitch on the 747's keel beam. The upward snap was so powerful it broke the ship's backbone. As the NTSB's report puts it: "The two vertical web attachments and the lower keel beam chords at the front lower bulkhead were fractured (LF14A, LF55C, LF55D, & LF55E). The lower chord fractures at the front spar exhibit evidence of bending in the vertical plane (crack initiating at the top of the chord's cross-section)." This is followed by "Metallurgical examination of the chords fractured at STA 1150 revealed bending in a vertical plane (crack initiated at the top of the chords' cross-sections) with a river pattern emanating from the upper surface of the fracture, which is indicative of downward bending." It was as if a pair of giant hands, one on the tail and the other on the forward section, broke the fuselage over an invisible knee. And, this before the alleged explosion occurred in the center wing tank.

Yet another item high on our list of loose ends are those EPR indicators mounted on the pilots' instrument panel, and frozen in time by the damage done to their inner mechanisms (see page 51). Had the 747's electrical power to these instruments failed before the damage that transfixed the indicators—which would have been a result of a catastrophic explosion in the CWT—all four indicator tapes would have instantly dropped to zero and four striped flags and the word 'OFF' would have snapped into view. Moreover, had the break-up occurred before the instruments were damaged, they could not have still indicated power as they did. The pitch-up would have disrupted the laminar flow of air into and through the turbines. That disruption would have been reflected in all of the EPR readings. Instead, the instruments, set approximately to climb power, read as follows: Nº 1—1.35; Nº 2—1.35; Nº 3—1.30; and Nº 4—1.23.

Based upon the low readings of Numbers 3 and 4, we believe the fuselage had just begun its fatal pitch-up. Thus, a crucial and revealing nanosecond of time was preserved. All of which returns us, once again, to the question: What was the source of the powerful concussion that disabled the EPRs?

Howard Mann has studied the chain of linked data recorded by TWA 800's DFDR. At time 20:31:11 (20hr 31min 11sec) on the tape, for example, Mann noticed a sudden flicker in the recorded position of a tiny wind vane mounted on the outside of the fuselage near the leading edge of the left wing. This tiny airfoil, part of the airplane's stall warning system, was designed to sense the relationship between the 747's longitudinal axis (an imaginary line running for nose to tail) and the air stream, or 'relative wind' (left). Within its normal range, the wind vane had been reading 3.6° of nose pitch-up. At 20:31:12 it suddenly shot up to 106°. This was followed by an indication of a steep 30° nose-up condition. The source of electrical power to the DFDR then failed. How much farther the nose of the 747 pitched upward is anyone's guess. But there can be little doubt that this pitch-up is what tore the wingtips off their respective inner wing panels. The close relationship between pitch-up and the interruption of electrical power to the wind vane must not be minimized.

These findings were discussed by Howard Mann with the late Commander William Donaldson, US Navy, Retired. The two began to correlate other indications that occurred within that time frame. They found that, just before they were frozen in place, Nº 1 and Nº 2 engines' EPR gauges had flickered. The pilots' altimeters, via their static vent ports (small openings on the side of the fuselage), sensed the shock wave as an increase in atmospheric pressure and momentarily indicated a bogus 3,672ft-dip in altitude. Donaldson did some



*TWA 800 fuselage reconstruction. A photograph taken by the NTSB of the left side of the fuselage. The site of the breach was roughly abeam the L2 door.*

*Original fuselage reconstruction. Another NTSB photograph shows that, unlike the left side, the skin of the right side of the forward section is splayed outward (that is from left to right). This is the result of a linear rather than an expanding omni-directional force emanating from the opposite side of the airframe.*

PHOTOS: NTSB

complicated mathematical calculations and was able to triangulate the epicenter of the blast. Accordingly, Donaldson placed the epicenter near the "Low[er] left side [of the fuselage]...abeam aircraft station 576." Donaldson adds: "9 feet [2.74m] below the aircraft belly line [and] 17 feet [5.18m] from closest aircraft hull" (left). An NTSB diagram depicts the L2 door, located nearly abeam the epicenter of the explosion, having been blown loose and expelled from left to right. The opposite would have been true had the explosive pressure emanated from the CWT.

An article published in *Aviation Week & Space Technology (AW&ST)* read, in part, "Investigators have determined that 'no missile hit this airplane,' the official said." That a missile did not strike the fuselage is a point that, based upon an examination of the wreckage, is easily conceded. However, the *AW&ST* story continued: "They are, however, weighing the extremely remote possibility that a missile self-destructed near TWA Flight 800 and flung a fragment into the center fuel tank. Physical evidence to assess this is scarce. A fragment and its initial damage to the tank likely would be small and difficult to find in the massive damage to the center tank." To this cautionary escape clause, *AW&ST* writer Michael A Dornheim added, "Investigators have detonated missile warheads at various distances from aircraft skin to study the resulting damage, and say they have found nothing similar on Flight 800's debris." But how closely did the alleged 'tests' replicate reality? We wonder if, in the process of carrying out these tests, the subject pieces of 'aircraft skin' were lumped together with other debris and mangled after the fashion of the real event? Which 'warheads' were tested? And, perhaps the most important question: If no tangible evidence of a missile had been found, why test 'warheads' at all?

On September 16, 1997, Southern California's *The Press-Enterprise* added support for the notion of an external explosion with an article headlined, 'TWA crash probe turns to damaged nose gear doors'. "The nose gear's doors were blown inward and investigators now wonder whether the cause of the damage happened before the plane's center fuel tank exploded, CNN reported, citing unnamed federal crash investigators." (see diagram opposite and the force vectors to the nose gear's wheel well doors.)

Mann's and Donaldson's meticulously constructed postulations begin to take on greater credibility. Drawing from the International Association of Machinists and Aerospace Workers, AFL-CIO, CLC's (IAM's) final report, we learn others are also concerned about such loose ends. Addressing the question as to the source of ignition to support the NTSB's conclusions, an obviously disgruntled R T Miller, the IAM's coordinator, wrote, "We conclude that the existing wiring recovered from Flight 800 wreckage does not exhibit any evidence of improper maintenance or any malfunction that lead to a spark or other discrepancy. Examination indicates that the wiring was airworthy and safe for flight."

Turning his attention to the question of the CWT explosion, Miller wrote, "The center wing tank did explode! We find that its explosion was as the result of the

aircraft breakup. The initial event caused a structural failure in the area of Flight Station 845 to 860, lower left side of the aircraft. A high-pressure event breached the fuselage and the fuselage unzipped due to the event. The [center wing fuel tank's] explosion was a result of this event!" According to the IAM's investigators, there was no evidence of excessive heat inside the forward cargo compartment, which is just forward of the CWT. A massive explosion in the CWT, as the primary event, would surely have made its way through and past the flimsy bulkhead that lay between the CWT and the cargo compartment.

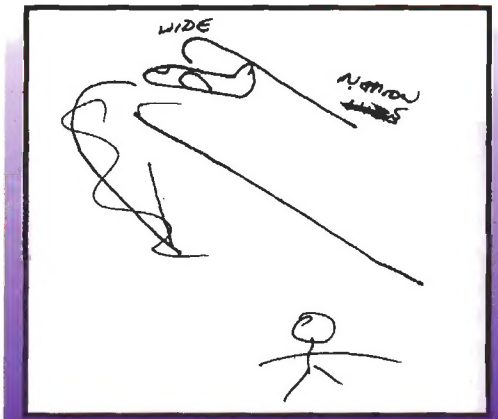
Returning to those immobilized EPR gauges, it will be recalled that their mechanisms were jammed in place before the pitch-up and necessarily before the electrical power was cut. The blast that splayed the metal of the right side of the forward fuselage appears to be the source of the shock wave.

Finally, to completely ignore eyewitness reports would devalue any process claiming the title of 'investigation'. Of the 755 witnesses listed in the NTSB report, our short list of loose ends contains only three. The first, whose name has been blacked out by the NTSB, is identified only as an adult female 'Number 73'. Here is her account: "On [July 17, 1996], at approximately 8:37 P.M., [Number 73] was on the MOBAY (phonetic) section of Long Island Beach, New York, when she observed an aircraft climbing in the sky traveling from her right to her left. [Number 73] advised that the sun was setting behind her. While keeping her eyes on the aircraft, she observed a 'RED STREAK' moving up from the ground toward the aircraft at approximately a 45 degree angle. The 'RED STREAK' was leaving a light gray colored smoke trail. The 'RED STREAK' went [past] the right side and above the aircraft before [arching] back toward the aircraft's right wing. [Number 73] described the [arch's] shape as resembling an upside down NIKE SWOOSH Logo. The smoke trail, which was light gray in color, was narrow initially and widened as it approached the aircraft. [Number 73] initially thought someone had set off a flare and commented same to her friends Scott and Pauline Barrows of Long Island. [Number 73] never took her eyes off the aircraft during this time. At the instant the smoke trail ended at the aircraft's right wing, [Number 73] heard a loud sharp noise which sounded like a firecracker had just exploded at her feet. [Number 73] then observed fire at the aircraft followed by one or two secondary explosions which had a deeper sound. [Number 73] observed the front of the aircraft separate from the back and then observed burning pieces of debris falling from the aircraft." Both the timing and the account of what 'Number 73' saw is very much in accord with the sequence of events we have described. Additionally, 'Number 73' gave the NTSB a sketch of what she had seen (right). Her drawing concurs with the sightings of other witnesses and, not surprisingly, bears a striking resemblance to the real event.

Our 'short list' of witnesses also includes Richard Goss. At the October 18, 1997, Accuracy In Media (AIM) meeting, Commander Donaldson described his interview with Mr Goss: "That evening [July 16, 1996] I was just finishing up a sunfish race at Westhampton Yacht Club...it was Wednesday night...and that particular night every week we have an informal sunfish race and then it's followed by a 'bring your own' barbecue dinner on the back porch of the yacht club. That porch faces south and my position at the table that I was sitting at I was looking right out at Moriches Bay and you know just leaning back, resting, just enjoying the moment of that part of the evening. It was near dusk and it was then that I saw a flare-type object go up and feeling that oh someone along Dune Road has fireworks and other members of the club saw it also and they said hey look at the fireworks. And everybody


GERARD ISAACSON

*US Army engineers transport the wreckage of TWA 800.*




GERARD ISAACSON

turned to look and we all watched it climb and I particularly watched it and it was bright, very bright, and you know that almost bright pink you know orange glow around it and it traveled up and it looked to go straight up from the area that I was observing it and then it reached its peak and it seemed to go away in the distance toward the south and that's when I saw it veer left which would bring it out east. It was a sharp left and then it did not disappear. From my vantage point there was a direct explosion that followed and then after that there was a second explosion that was off to the east a little farther that was much larger...it was like something broke off of whatever that was that caught fire. The smoke was black...it was obviously some petroleum. I knew it was an airplane or aircraft of some sort and I didn't realize what size it was. And then it took some time to come down... probably three or four seconds and there was just a stream of black and white smoke and then when it hit the horizon over the barrier beach...Dune Road... and when it hit the horizon there was a bright flash."

Both witnesses, 'Number 73' and Richard Goss, observed similar colorations and noticed that the unidentified object turned left before the first explosion. Both reported more than one explosion.

Finally, our 'short list' contains Fred Meyer, an ex-Navy officer and Vietnam War helicopter pilot. On the day of the tragedy, Meyer was a National Guard helicopter pilot who was in the process of practicing an instrument approach at Westhampton Beach at the Francis S Gabreski Airport. Interviewed by Michael Hull: "Meyer's attention was first called to the area [where Flight 800 was located]...'by a streak of light moving from my right to my left (east),' the same direction as the TWA flight, he said...Baur [Meyer's co-pilot], on the left side of the cockpit, saw a streak moving from left to right toward the approaching TWA aircraft before the initial explosion. The streak of light that Meyer saw... was red-orange in color...what Meyer describes as a hard, very sudden, yellowish-white explosion that looked identical to the detonation of an anti-aircraft shell. 'It left a cloud of smoke just like a flak explosion does,' Meyer said. Meyer said, 'One or two seconds later, there was a second, hard explosion almost pure white in color...almost immediately there was a third explosion and a fireball.' Baur also saw three explosions...he also contends that they started from the left (east) and went right (west). Later, Frederick Meyer told reporter David E Hendrix of *The Press-Enterprise*, "I know what I saw. I saw an ordnance explosion. And whatever I saw, the explosion of the fuel was not the initiator of the event. It was one of the results."

Our presentation by no means includes all of the many loose ends. We feel that, despite going about it backward—beginning with the end of the tragedy and ending with the beginning—we have offered enough evidence to provide an accurate overview. Reliable eyewitnesses saw a missile-like object rise from the surface of the Earth and adjust its own course so as to connect with the ill-fated 747. These witnesses saw multiple explosions. The coherence of their observations could hardly have been the result of mere coincidence. They also harmonize with the evidence gained from the recovered wreckage. The initial explosion precipitated only the beginning of the break-up of the airliner. A second, more devastating blast ripped the airplane to shreds.

We know nothing of military ordnance, and too little of politics or terrorism, for us to speculate about specifically what initially exploded near the climbing 747, or whence it came. Our only possible submission is what seems to us to be obvious: Something more than just fuel vapors in the CWT erupted and, until the entire event is fully and honestly explored, the sad story of TWA Flight 800 will remain incomplete. The NTSB's 'Probable Cause', as another loose end, is wrong. Maybe the resolution of this important detail will tell us why the NTSB failed. TWA

*Authors' note: This summary is based on extracts from the following publications and reports:*

*NTSB: DCA-96-MA-070;* November 17, 1997.

Addendum, by Howard Mann, to *Interim Report on the Crash of TWA Flight 800 and the Actions of the NTSB and the FBI* by (the late) Commander William S Donaldson II, USN Retd (Copyright 1998).

*NTSB Group Chairman Factual Report.*

*Systems Group Chairman's Factual Report of Investigation;* November 17, 1997.

*NTSB Structure Group Chairman's Factual Report* (DCA-96-MA-070); February 20, 1997.

International Association of Machinist and Aerospace Workers, AFL-CIO: *Analysis And Recommendations Regarding TWA Flight 800, July 17, 1996.*

*Aviation Week & Space Technology (AW&ST);* various issues including December 23/30, 1996; June 16, 1997; July 21, 1997; December 15, 1997.